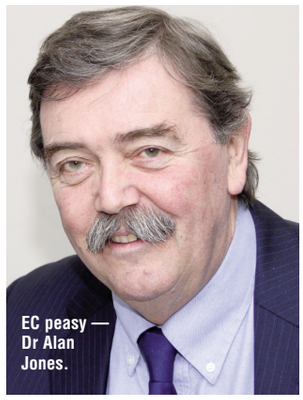
Fans of energy efficiency

Does a 90% reduction in the energy used by fans in fan-coil units interest you? And what about increasing a building's asset rating at the same time? **Ken Sharpe** looks at a simulation carried out by EDSL Tas and Trox.



EC peasy — Dr Alan Jones.

"Even the simple act of replacing AC with EC in a constant-volume system will realise a payback of three years and nine months. Exploiting the variable-speed capabilities of EC motors will reduce the payback period by over a quarter to two years and eight months"

It's common sense, isn't it, that fan-coil units with variable-speed motors driving their fans will use less energy and, therefore, be more energy efficient than fan-coil units with their fans operating at constant speed to deliver a constant airflow. That much is apparent from the fan laws, with, for example, reducing the air volume by just 20% halving the fan power required.

But how does that basic information translate into real-life operation and other benefits?

You can get some indication from laboratory mock-ups, but it is very difficult to build up a long term picture in this way. Much easier to do is to use building-simulation software to model the operation of a building over very short periods of time — say as little as half-hourly intervals.

That is just what EDSL Tas and Trox UK have done, using algorithms developed from actual test data from Trox's facilities at Thetford. That data is described by Dr Alan Jones, managing director of EDSL Tas as 'of sufficient detail to allow conclusions on potential benefits to be drawn'.

Before we look in more detail at the assumptions of the simulation, let's jump to the final answer — since readers have a habit of doing that anyway. It is an answer that surprised both Dr Jones and Barry Trewhitt (project manager, systems, with Trox UK) — namely that the annual fan-motor energy consumption of an air-conditioning system using fan-coil units with variable-speed fan operation was 90% less than their constant-speed counterparts.

And, as will become apparent later, that huge reduction in fan power has a significant effect on a building's carbon emissions. One that was modelled by EDSL Tas for Land Securities saw a simple change from fan-coil units with constant air volume to units with variable air volume reduce predicted CO2 emissions by over 12%. With the 2010 Building Regulations now taking effect and requiring a 25% reduction in carbon footprint compared with the 2006 regulations, that is a significant reduction.

The study compared two fan-coil units. One was a basic constant-volume unit with an AC motor. The other was a Trox VAV fan-coil unit with a variable-speed EC motor. Both had water-side control of cooling capacity. They were assumed to be operating with flow/return temperatures of 11/15°C in cooling mode and 82/71°C in heating mode.

The control sequence is crucial to the results achieved in the simulation, and is shown in the two diagrams in Fig. 1. The important differences are the narrower proportional bands for heating and cooling with the VAV system and, even more important, how the fan speed is varied.

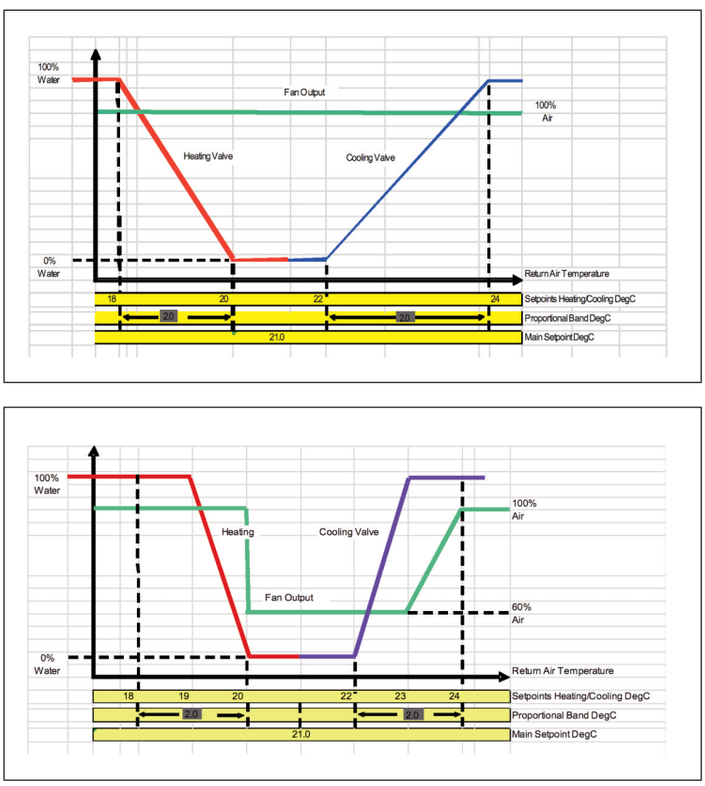
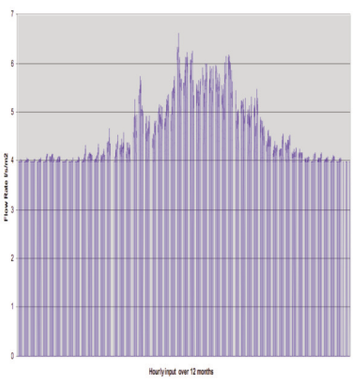


Fig. 1: Compared with fan-coil units operating at constant air volume, a unit that exploits the variable-speed capabilities of its fan can achieve huge savings in the energy used to move the air.



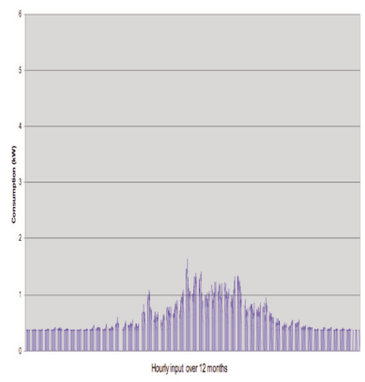


Fig. 2: Varying the speed of a fan with a EC motor can save huge amounts of energy over a year. For comparison, the power consumption of a constant-volume system with an AC motor would be 5.3 kW.

Note in particular how the fan speed is reduced to deliver 60% airflow when the heating demand is met. This is to avoid the coanda effect breaking down when cooling comes into effect. If the airflow was reduced more, the coanda effect of air flowing across the ceiling would be lost — and not re-established until the airflow was increased to 80%.

Without going into too much detail about the model building, let's just say it is a 3-storey building 30 m square divided into perimeter and core zones according to the National Calculation Methodology and designed to 2006 Building Regulations.

A specific fan power of 0.6 W/l/s was assumed for the constant-volume FCU and 0.25 W/l/s for the units with EC motors. Alan Jones observes that even at constant-speed operation, the EC motor would be expected to more than halve fan energy consumption — with even more saving from variable-speed operation.

From hourly information about the building cooling and heating loads and test data from Trox, it was possible to generate an hourly analysis of airflow and fan power for an installation comprising VAV FCU with EC motors (Fig. 2). The analysis assumes that the installation is exactly matched to the requirement, as evidenced by the airflow rate reaching 100% for only a very few hours a year. For most of the year, the power drawn by the EC motors is less than 10% of that drawn by constant-speed AC motors — which is where the 90% energy saving referred to earlier comes from. Much of the reduction in annual energy consumption is due to the lower specific fan power of the EC fans, which is further enhanced by reducing the speed.

The efficiency of EC motors compared with AC motors can offer attractive paybacks. Even the simple act of replacing AC with EC in a constant-volume system will realise a payback of three years and nine months. Exploiting the variable-speed capabilities of EC motors will reduce the payback period by over a quarterto two years and eight months — for the same extra capital cost.

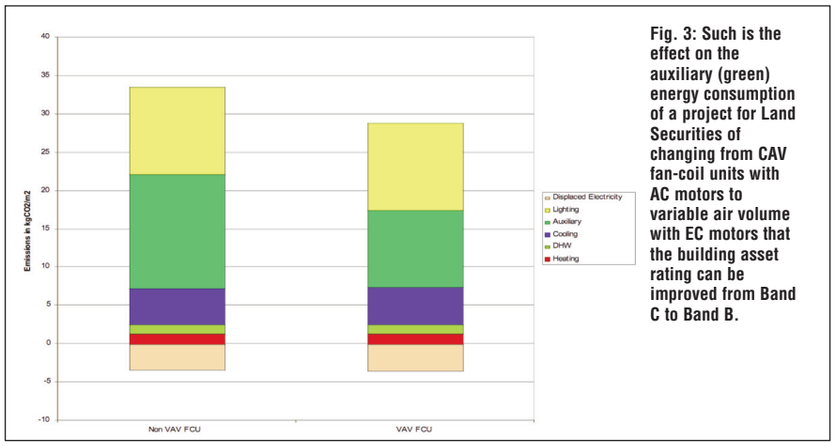


Fig. 3: Such is the effect on the auxiliary (green) energy consumption of a project for Land Securities of changing from CAV fan-coil units with AC motors to variable air volume with EC motors that the building asset rating can be improved from Band C to Band B.

The lower energy consumption of VAV systems compared with CAV can also have a marked effect on a building's Energy Performance Certificate and the BER (building energy rating) as calculated to obtain planning permission. An analysis carried out for a project for Land Securities that is expected to start this year shows just that (Fig.3).

With constant-speed operation of the fan-coil units, the simulation indicated a Building Asset Rating of 57, near the top of Band C. VAV operation improves the Building Asset Rating to 48, pushing it up into Band B.

The auxiliary load of the building (terminal fans, main AHU fans and pumps) is reduced by nearly a third, amounting to a 15.7% improvement in the BER from 30 to 25.3 kg/m^2 of CO2.

When they embarked upon these simulations neither Dr Alan Jones and Barry Trewhitt expected the benefits of speed controlled EC motors to be quite so dramatic. But Alan Jones is confident of their validity, explaining, 'The algorithms used have been developed from actual test data and are of sufficient detail to allow conclusions on potential benefits to be drawn.'